PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [4] : F01N 1/06	A1	(11) International Publication Number: WO 89/ 07701
		(43) International Publication Date: 24 August 1989 (24.08.89)

(21) International Application Number: PCT/US89/00665

(22) International Filing Date: 17 February 1989 (17.02.89)

(31) Priority Application Number: 158,883

(32) Priority Date: 19 February 1988 (19.02.88)

(33) Priority Country: US

(60) Parent Application or Grant
(63) Related by Continuation
US 158,883 (CIP)
Filed on 19 February 1988 (19.02.88)

(71) Applicant *(for all designated States except US)*: NOISE CANCELLATION TECHNOLOGIES, INC. [US/US]; 10015 Old Columbia Rd., Ste. F100, Columbia, MD 21046 (US).

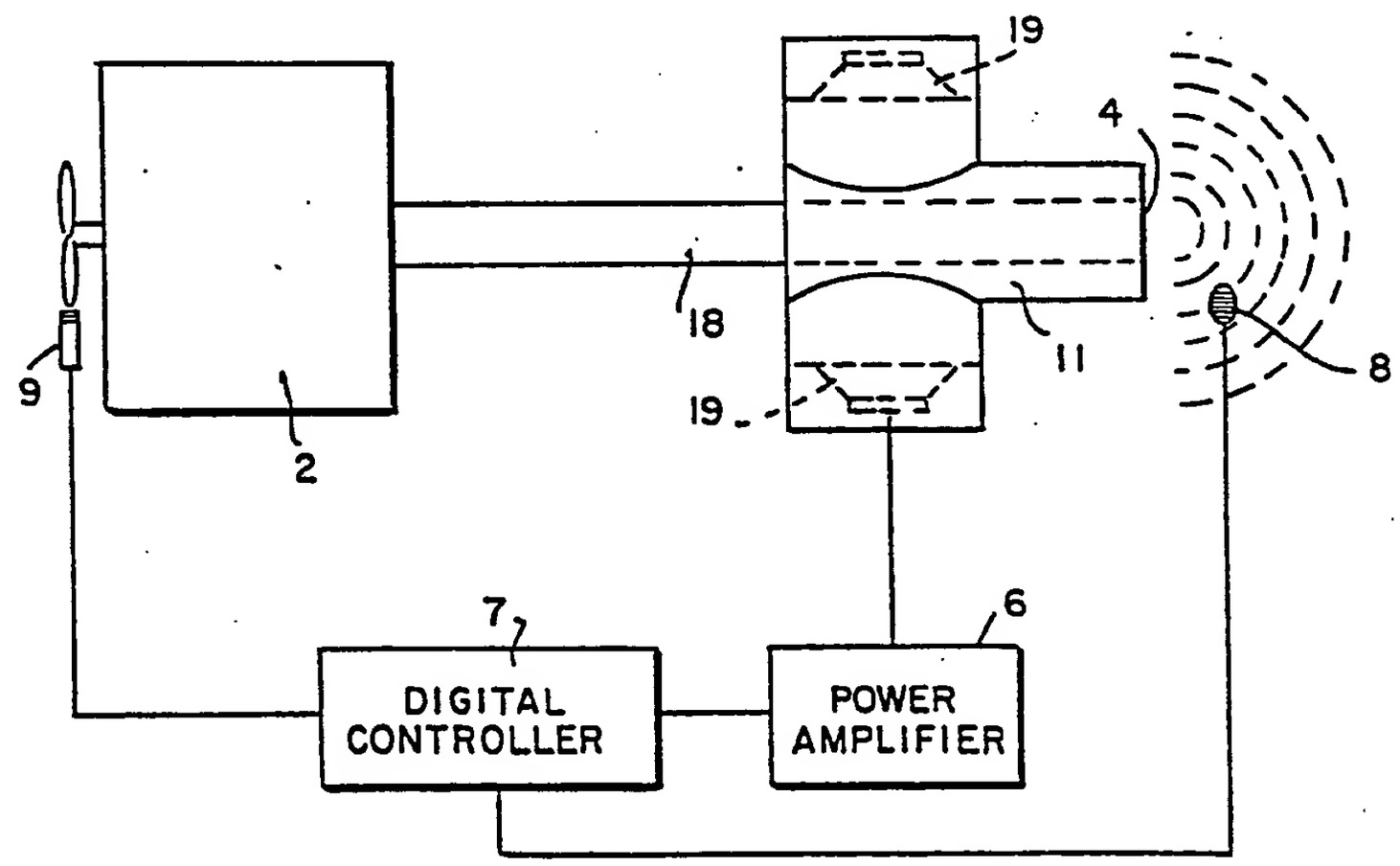
(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : GARDNER, John, W. [US/US]; 3105 Weller Road, Silver Spring, MD 20906 (US). ZIEGLER, Eldon, W., Jr. [US/US]; 10092 Hatbrin Terrace, Columbia, MD 21046 (US).

(74) Agent: EVENSON, Donald, D.; Barnes & Thornburg, 1815 H Street, N.W., 8th Floor, Washington, DC 20006 (US).

(81) Designated States: AU, BR, DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KR, SE (European patent), SU, US.

Published
With international search report.

(54) Title: ACTIVE SOUND ATTENUATION SYSTEM FOR ENGINE EXHAUST SYSTEMS AND THE LIKE



(57) Abstract

An active sound attenuation system for combustion engine exhaust systems and the like is disclosed. The system includes counter-noise acoustic wave generators (19) that are protected from the environment of a medium propagating undesireable noise by an acoustically tuned anti-noise chamber (5, 11) interposed between the wave generators (19) and the medium with the undesirable noise. To provide for noise cancellation at an outlet end (4) of an exhaust pipe (10) the anti-noise chamber (5, 11) has an annular opening disposed substantially in the plane of the exhaust pipe outlet thereby giving an effective common point source for the propagated undesirable noise and the counter-noise acoustic wave.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
BB	Barbados	GB	United Kingdom	MW	Malawi
BE	Belgium	HU	Hungary	NL	Netherlands
BG	Bulgaria	IT	Italy	NO	Norway
BJ	Benin	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
DE	Germany, Federal Republic of	LU	Luxembourg	TG	Togo
DK	Denmark	MC	Monaco	US	United States of America
FI	Finland	MG	Madagascar		

ACTIVE SOUND ATTENUATION SYSTEM FOR ENGINE EXHAUST SYSTEMS AND THE LIKE

of which the following is the specification.

BACKGROUND AND SUMMARY OF THE INVENTION

This is a Continuation-in-Part Application of U.S. Patent Application Serial No. 07/158,883, filed February 19, 1988.

The present invention is related to an improved arrangement for reducing intake and/or exhaust noises from combustion engines and the like. More specifically, the present invention relates to a new sound attenuation arrangement for such apparatus which uses anti-noise or counter-noise acoustic wave generators to attenuate the sound generated in such apparatus. Various aspects of the present invention can be utilized in attenuating sound in combustion engine intake and exhaust systems, in compressors, and in pumps and the like. The preferred embodiment of the invention described refer primarily to combustion engines, however, it is to be understood that the invention is adaptable to attenuate sound in other arrangements exhibiting similar noise generating configurations such as in the intake and exhaust of certain compressor and pumps and the like.

Numerous passive systems for suppressing noise at the intake and/or exhaust of gas movement systems have been proposed previously. Such passive systems use sound insulating material and/or baffles to suppress sound waves before they reach the surrounding atmosphere. These so-called "passive systems", such as conventional automotive exhaust gas mufflers, inherently restrict the exhaust gas flow, thereby resulting in energy losses with reductions in the efficiency of operation of the vehicle combustion engines. It is well known to those skilled in the art of internal combustion engines that reduction or removal of the

exhaust gas restriction back pressure substantially improves the performance of the engine. However, permitting such "straight pipe" operation of automotive vehicles results in sound patterns in public places that are not only unpleasant, they are unhealthy. For these reasons, virtually every industrialized nation has restrictions on the level of noise propagation that can be generated by automotive vehicles and other machinery operating in public places. To date, in order to satisfy these noise abatement restrictions, virtually all automotive vehicles have relied on the passive muffler systems with consequent reduction in engine efficiency. Coupled with the reduction in engine efficiency there is of course inherent increased pollution due to increased hydrocarbon fuel consumption.

So-called "active" noise-cancellation systems have been proposed in the past and adapted to certain environments on a small scale, usually environments involving relatively constant frequency sound generation pattern of the type that might be experienced in a fixed combustion engine constant velocity operating for a generator station or the like. U.S. Patents 4,122,303; 4,489,441; and 4,527,282 to Chaplin et al. disclose various aspects of active noise cancellation systems. French Patent 1,190,317 to Sherrer; U.S. Patents 4,677,676 and 4,677,677 to Eriksson, and U.S. Patent 4,473,906 to Wannaka disclose additional methods for active noise cancellation in building system air ducts or exhaust pipes in which the cancelling noise generator (speaker) is required to be exposed directly to the exhaust gas stream. Those systems requiring placement of the speakers in the exhaust gas stream generating the undesirable

sound to be cancelled place the speakers in such a harsh chemical and heat environment that they cannot operate over an extended period of time, at least not without inordinate costs for insulating the speaker and/or designing them to withstand the loud environment. Further, such placement restricts the flow of exhaust gases to some extent, thereby resulting in the above-mentioned disadvantages regarding the back pressure on the combustion engine. Furthermore, those prior art systems that have been utilized in exhaust environments do not exhibit the compactness to facilitate commercialization and use on automotive and marine passenger vehicles and also do not have control systems that are responsive to the varying noise spectrum generated during the normal driving of such vehicles, with acceleration and deceleration over a wide range of vehicle engine speeds.

An object of the present invention is to provide an improved active noise cancellation system that is compatible with the operating conditions of motor vehicle combustion engine exhaust systems and the like. Another object of the invention is to provide a system that will suppress noise generated from rapidly changing noise sources such as experienced in motor vehicle exhaust systems during normal driving operations and the like. Another object of the invention is to provide a compact, economical to manufacture sound cancellation system that can be incorporated into mass production vehicles with a consequent substantial reduction in the overall costs of operating such vehicles as compared with vehicles having conventional passive muffler systems.

These and other objects are achieved according to the invention by providing a sound attenuation system which exhibits one or more of the following characteristics:

(i) an anti-noise chamber is interposed between the anti-noise acoustic wave generators and the fluid guide system for the fluid medium propagating the undesirable noise, thereby protecting the anti-noise acoustic wave generators from any harsh environment of the undesirable noise propagating medium;

(ii) the anti-noise acoustic wave generators open into an acoustically tuned anti-noise chamber which in turn opens to the fluid medium propagating the undesirable noise thereby enhancing the effective efficiency of the anti-noise acoustic wave generator; and

(iii) the anti-noise acoustic waves are introduced into the medium propagating the undesirable sound at a position so that the effective source of both the undesirable sound and the anti-noise sound is substantially nearly coincidental, thereby enhancing efficient global cancellation of the undesirable sound.

In certain preferred embodiments of the present invention an active noise attenuation system is so constructed as to avoid the placement of the anti-noise acoustic wave generators into the environment of fluid flow propagation the undesirable noise, such as the harsh environment of the exhaust gases of a vehicle exhaust system. In especially preferred embodiments, the attenuation system includes an anti-noise chamber which surrounds over a portion of its length, a centrally disposed engine exhaust pipe, with the anti-noise chamber and exhaust pipe opening to atmosphere

in substantially the same plane, and at least within a length corresponding to less than one third of the shortest wave length of the undesirable noise to be attenuated. The anti-noise speakers open into the anti-noise chamber, which is totally isolated from the exhaust pipe and thereby the speakers are not subjected to the harsh chemical and heat environment of the exhaust gases.

In certain especially preferred embodiments for use with automotive exhaust systems, the anti-noise chamber is constructed as an acoustically tuned annular chamber concentric with the exhaust pipe. In especially preferred embodiments, the anti-noise speakers are symmetrically arranged around the axis of the exhaust pipe and anti-noise chamber. The anti-noise chamber is constructed as a first, relatively large diameter section which is closed off at one end by an annular supporting plate that is connected to the exhaust pipe, the speakers being mounted adjacent that end plate. The anti-noise chamber then extends in the downstream direction of the exhaust pipe and opens at the same plane as the atmospheric outlet of the exhaust pipe, thereby providing an effective coincidental sound source for both the anti-noise sound waves and the undesirable sound waves from the exhaust pipe, with consequent "global" noise cancellation.

According to certain preferred embodiments of the invention, the anti-noise acoustic wave generators are controlled by a digital controller which has inputs from a synchronization sensor monitoring the engine rotational speed and a residual sensor microphone which picks up the sound at the outlet of the exhaust pipe. These sync sensor and microphone signals are processed by

the controller and drive power amplifiers for the anti-noise speakers.

According to other preferred embodiments of the control system for the anti-noise acoustic wave generators, an upstream sensor microphone picks up the sound in the exhaust pipe upstream of the location of the anti-noise chamber and feeds its signal to the digital controller, the other signal to the controller being from a residual sensor microphone at the outlet end of the exhaust pipe. As in the other embodiments referred to in the immediately preceeding paragraph, the digital controller processes this sensed information and accordingly controls and drives the anti-noise acoustic wave generators to cancel the sound.

Although the preferred embodiments descrbied involve vehicle combustion engine exhaust systems, preferred embodiments of the invention are also contemplated for engine intake systems, for compressors and pumps with undesirable sound waves propagated in a pipe exhausting to atmosphere, and the like.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic side view of a passenger vehicle depicting the location of the engine exhaust system and a digital muffler system constructed according to a preferred embodiment of the present invention;

Figure 2 is a schematic bottom view of the vehicle of Figure 1 depicting the vehicle exhaust system and active digital muffler system constructed according to a preferred embodiment of the present invention;

Figure 3 is a side schematic view of a motor boat equipped with another preferred embodiment of the present invention;

Figure 4 is a schematic view showing the engine, exhaust system and active digital muffler system for use with the boat of Figure 3;

Figure 5 is a schematic perspective view of an exhaust muffler arrangement constructed according to a preferred embodiment of the present invention;

Figure 6 is a longitudinal section view of the muffler arrangement of Figure 5;

Figure 7 is an end view taken from the right side of Figure 6;

Figure 8 is a view similar to Figure 6, showing an alternative of the exhaust muffler arrangement of the present invention, having an intermediate exhaust gas low pressure cooling chamber;

Figure 9 is an end view from the right side of Figure 8;

Figure 10 is a schematic depiction of a complete active digital muffler system constructed according to a preferred embodiment of the present invention;

Figure 11 is a schematic depiction of a complete active digital muffler system constructed according to another preferred embodiment of the present invention;

Figure 12 is a graph comparing test results on a vehicle with a diesel engine, showing the sound spectrum at the exhaust with

and without noise attenuation using the system of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 schematically depict respective side views and bottom views of a passenger motor vehicle having an active digital muffler system constructed according to preferred embodiments of the present invention. The system depicted in Figures 1 and 2 corresponds to the Figure 10 embodiment of the overall system (described in more detail below). The passenger vehicle 1 includes a multi-cylinder/piston internal combustion engine 2, the exhaust of which is transported by exhaust pipe system 3 to the exhaust outlet 4 at the rear of the vehicle. The rear portion of the exhaust pipe system 3, is depicted as a single exhaust pipe in the following description, although similar duplicate arrangements can be provided for dual exhaust pipe systems, is provided at its rear end with a surrounding anti-noise chamber arrangement 5, which includes anti-noise speakers driven by a power amplifier 6 and digital controller 7. The digital controller 7 has input signals from a residual sensing microphone 8 adjacent the exhaust outlet 4 and a synchronization sensor 9, such as a tachometer at the drive shaft of the engine 2.

Figures 3 and 4 schematically depict a preferred embodiment of an active digital muffler system according to the invention installed on a motor boat 1A, which, in a similar manner as the passenger motor vehicle of Figures 1 and 2, includes a reciprocating piston multi-cylinder internal combustion engine 2A,

an exhaust pipe system 3A with an outlet 4A. An anti-noise chamber arrangement 5A is provided adjacent the downstream end of the exhaust pipe system 3 and includes speakers driven by a power amplifier 6A and controlled by a digital controller 7A. The digital controller 7A is in turn supplied with input signals from a residual sensor microphone 8A, the exhaust outlet of the boat motor and a synchronization sensor 9A of the output drive shaft of the boat motor engine 2. Certain embodiments for use with boats will include water supplied exhaust system cooling arrangements, such as water flow directly into the exhaust pipe and water flow in an annular jacket surrounding the exhaust such cooling arrangement being well known in the motor boat industry.

The following description of the details of the anti-noise chamber arrangement surrounding the exhaust pipe and the controller circuit for controlling the same is similar for the embodiments for both the over the road passenger motor vehicles of Figures 1 and 2 and the motor boat of Figures 3 and 4. It will be understood by those skilled in the art that certain components in the motor boat environment need to be "marine" qualified to withstand salt sea air and the like.

Figures 5-7 schematically depict a first preferred embodiment of an anti-noise chamber arrangement 5 and exhaust pipe. Chamber 5 of Figures 6-7 is constructed as an intregal sheet metal structure and includes a centrally disposed cylindrical exhaust pipe 10 which is connected to the exhaust pipe system 3, 3A (compare Figures 1 to 4). The left hand end of the exhaust pipe section 10 is preferably configured so as to be insertable into an existing exhaust pipe of an engine exhaust system 3,3A, with an appropriate sealing clamping connection being provided.

An anti-noise chamber 11 is provided in annular surrounding relationship to the exhaust pipe 10. The anti-noise chamber 11 is defined by first cylindrical section 12 of a large diameter and an adjoining smaller diameter section 13. The left hand end of the large diameter section 12 is closed off by an annular end plate 13 which is supported at the outer surface of the exhaust pipe 10 by welding connection 14. The opposite end of the anti-noise chamber 11 is supported by radially extending support plates 15 attached by welding 16 at the exhaust pipe 2 and by welding 17 at the anti-noise chamber 13. A pair of cylindrical speaker support sections 17 are connected by a welding connection 18 to the cylindrical section 12 at a position adjacent the end cap 13. In the illustrated embodiment the cylindrical speaker support sections 17 have a slightly smaller diameter than the diameter of the section 12 of the anti-noise chamber and are there joined by welding seams 18. These anti-noise speaker support cylinder sections 17 are disposed symmetrically with respect to the longitudinal axis of the exhaust pipe 10 and anti-noise chamber 11. Anti-noise speakers 19 are mounted in each of the respective support section 17 and are disposed to generate sound waves emenating into the anti-noise chamber 11. The anti-noise chamber 11 is concentric and to separate from the exhaust pipe 10, with the anti-noise sound waves generated by the speaker 19 and propagated along the length of the member 11 opening into the atmosphere at the same exit plane 4 as the exhaust gases from the exhaust pipe 10.

By arranging the speakers 19 to be symmetrical with the longitudinal axis of the exhaust pipe 10 and by providing the

anti-noise chamber 11 as an annular chamber surrounding the pipe 10, the manufacture of the anti-noise muffler chamber arrangement is quite simple and it can be constructed as a unit that can be added on to an existing exhaust system 3 merely by connecting the left hand end of the pipe section 10 to the exhaust pipe of a vehicle. In especially preferred embodiments, the exhaust pipe 2 and the cylindrical sections 12, 13 making up the anti-noise chamber 11 and the speaker supports 17 are all constructed of metal that can be easily welded together, thus further simplifying the manufacturing operation. Embodiments are also contemplated with a heat insulating connection at the exhaust pipe 10 such as an annular heat insulating material ring surrounding the pipe 10 which limits the transfer of heat to the components. Since the speakers 19 are disposed symmetrically with respect to the noise generating exhaust pipe 10, an especially efficient utilization of space and cancellation of noise is provided since ther is symmetrical disposition of the anti-noise waves around the annular space at the outlet end 4 of the muffler pipe arrangement. Since the noise cancelling sound waves emanate in substantially the same plane or the exhaust gases, the anti-sound wave propagation is symmetrical with the sound wave propagation from the exhaust pipe outlet, thereby simplifying the construction and operation. The speakers 19 are also isolated by chamber 11 from the exhaust gases and thereby do not have to withstand the highly corrosive hot gases in the exhaust stream.

Other preferred embodiments are contemplated which utilize only a single speaker opening into the acoustically tuned chamber 11, the annular outlet at plane 4 effectively providing an

appropriate effective common point source for the cancelling and undesired sound. The additional speakers of the preferred embodiments illustrated facilitate the use of smaller speakers for the same output, thus economizing space. Also embodiments are contemplated where the speakers are remote from the chamber 11, with the sound waves transmitted by ducting to open into chamber 11, such arrangements being practical where space considerations are important such as in passenger automobiles, and the like.

In an especially preferred practical embodiment, the dimensions are as follows referring to Figure 6:

diameter 10 of the exhaust pipe 10 is 2.250 inches inside diameter,

the length 13 between end plate 13 and the left end of the pipe 10 is 2 inches,

the radial width 12R of the chamber section 12 outside of the pipe 10 is 1.75 inches,

the radial width 13R between the outside of the pipe 10 and the outer wall of cylindrical section 12 is .75 inches,

the radial length of the speaker support sections 17, 17R is 2.5 inches,

the diameter of the cylindrical sections 17, 17D is 5 inches,

the distance between the edge of the sections 17 and the end chamber section 12, 12L is 4.75 inches,

and the length 13L of the section 13 is 5 inches.

The embodiment of Figures 8 and 9 is the same as the embodiment of Figures 5 through 7 described above, except for the

addition of an intermediate low pressure cooling exhaust gas chamber 20 between the anti-noise chamber 11A and the exhaust pipe. In Figures 8 and 9, like reference numerals with a suffix A will be included to designate corresponding structure from the embodiment of Figures 5 through 8. These structures are described only to the extent that they function differently from the corresponding structure embodiment of Figures 5 and 8. The annular intermediate chamber 20 is communicated with the exhaust pipe 10A by eight radially extending 1/8 inch diameter holes 21 in the pipe 10A. The holes 21 are disposed at the upstream end of the anti-noise chamber 11 and allow a small amount of cooling air to be sucked in by the exhaust gas flow through the opening at end plane 4A so cooling air flows in chamber 20 counter to the direction of flow of the exhaust gases and then into the exhaust pipe. The radially extending reinforcing plates 15 extend also through the end portion of this chamber 20 and support the respective concentric pipes forming same. The cooling air flow communicated to the exhaust pipe through openings 21 also aid in reducing the turbulence of the exhaust gases that exit from the exhaust pipe 10A and thereby further reduce over all noise levels.

Figure 10 schematically depicts a first embodiment of a control system for the active digital muffler system of the present invention. A synchronization sensor such as an engine tachometer 9 provides synchronization signal inputs to a digital controller 7 which is also supplied by a residual sensor microphone 8 which picks up the actual sound wave pattern downstream of the outlet 4 of the exhaust pipe 10 and the anti-noise chamber 11 the controller 7 controls power amplifier 6

which in turn drives the speakers 19 to generate the noise-cancelling waves in the chamber 11, which then travel to the outlet plane 4 of the exhaust pipe 10 and effect cancellation of the sound waves emenating from the pipe outlet. In especially preferred embodiments, the audio power amplifier 6 is integrated with the digital electronic controller 7. The digital controller can utilize a frequency domain alogorithm as described in U.S. Patent 4,490,841 by Chaplin. Alternatively, the digital controller can utilize a time domain alogorithm as described in co-inventor Eldon Ziegler, Jr.'s pending U.S. Patent Application Serial No. 238,188 filed on August 30, 1988.

A practical speaker and microphone usalbe with a configuration as in Figures 5-7 or 8 and 9 has the following characteristics.

SPEAKER

MAGNET FLUX DENSITY 11,000 GAUSS

TOTAL FLUX - 58,000 MAXWELLS

SENSITIVITY 96dB spc@ 1m, 11.2 v RMS

THEIL-SMALL PARAMETERS

S_D = 92 cm^2

M_D = 9.8 gm

X_D = 6 mm peak to peak

f_s = 37 HZ

Rms = 1 Ω

Cms = 1.8×10^{-3} M/N

VAS = 23.6 liters

QM = 2.44

QE = 0.38

QT = 0.33

IMPEDANCE 8 Ω

RANGE 55 H_Z to 3,500 H_Z

NET WEIGHT 1.13 kg.

MICROPHONE

FREQ. RESPONSE 20 - 13,000 HZ

IMPEDANCE 600

SENSITIVITY -71dB ± 5dB

(REF OJB = 1v/μbar, 1KHZ)

POWER 1.5 VDC to 20 VDC-

A second control system for the active digital muffler system is schematically depicted in Figure 11. Since the Figure 11 system only differs from the Figure 10 system in the utilization of an upstream sensor microphone 22, in lieu of the tachometer synchronizing sensor 9, the remaining structure is depicted by similar reference numerals as in Figure 10. Similarly to the Figure 10 embodiment, either of a frequency domain alogorithm controller or a time domain alogorithm controller can be utilized. The difference between the Figure 10 and 11 embodiment being that the input from microphone 22 is utilized instead of the input from a tachometer sensor 9 as in Figure 10.

It is further noted that a controller corresponding to the NCT 20C0 controller marketed by Noise Cancellation Technologies Inc., can be used to serve as controller 7.

Figure 12 is a graphical comparison showing a dramatic reduction in noise levels utilizing the active digital muffler system on a diesel engine, as compared with operating the same diesel engine without cancellation. In Figure 12 the upper graph shows the noise levels without cancellation and the lower graph shows the noise levels with cancellation. The following is a Table of the experimental results shown on the Figure 12 graph.

MARK	LIST X	Y(U)	Y(L)
0	90.000	-18.0	-44.5
1	104.99	-45.3	-51.8
2	120.00	-45.9	-53.4
3	135.00	-41.8	-59.7
4	150.00	-38.3	-60.3
5	165.00	-45.9	-56.0
6	180.00	-24.8	-49.4
7	240.00	-36.1	-58.2
8	270.00	-40.8	-58.2
9	360.00	-46.1	-52.2

From the Table and the graph, one can see substantial noise level reductions, e.g. 26 decibels at mark 0 at 90 HZ frequency with the engine exhaust noise silenced by the sound attenuation system by the present invention, the passive muffler can be deleted from the vehicle exhaust pipe system. Deletion of the passive muffler (so-called "straight pipe" operations) results in remarkable increases in engine efficiency and power, as is known to those skilled in the art of automotive internal combustion engines.

Although the present invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only, and is not to be taken by way of limitation. The spirit and scope of the present invention are to be limited only by the terms of the appended claims.

WE CLAIM:

1. Exhaust gas muffler arrangement for combustion engine, comprising:

exhaust pipe means for communicating engine exhaust gases to surrounding ambient atmosphere at an exhaust pipe outlet opening means,

anti-noise chamber means surrounding the exhaust pipe means and opening to the atmosphere via anti-noise exhaust gas opening means at a position substantially in the same plane as the exhaust pipe outlet opening means,

and anti-noise speaker means facing into the anti-noise chamber means for generating anti-noise sound waves in the anti-noise chamber means such that the anti-noise sound waves and original noise sound waves in the exhaust pipe means cancel the effect of one another at the region of the exhaust pipe outlet opening means to reduce the overall noise level of the arrangement.

2. An arrangement according to Claim 1, wherein the exhaust pipe means and the anti-noise chamber means are dimensioned and configured such that at least a substantial majority of the exhaust gases flow through the exhaust pipe to atmosphere at the exhaust pipe outlet opening means in bypassing relation to the anti-noise chamber.

3. An arrangement according to Claim 1, wherein all of the exhaust gases flow to atmosphere in by passing relationship to the anti-noise chamber such that no exhaust gases are communicated to the anti-noise speaker means.

4. An arrangement according to Claim 3, wherein said anti-noise speaker means are disposed at an axial position of the exhaust pipe means upstream of the exhaust pipe outlet opening means.

5. An arrangement according to Claim 3, wherein said anti-noise chamber means is an annular chamber which completely surrounds a portion of the axial length of the exhaust pipe means.

6. An arrangement according to Claim 5, wherein said anti-noise chamber means acoustically tuned and includes a large diameter section joined by a smaller diameter section, said anti-noise speaker means being mounted at the large diameter section, said smaller diameter section extending to the exhaust pipe outlet means.

7. An arrangement according to Claim 6, wherein said anti-noise chamber means is symmetrically configured with respect to a longitudinal axis through the center of the exhaust pipe means.

8. An arrangement according to Claim 7, wherein said anti-noise speaker means includes a plurality of speaker means disposed symmetrically with respect to one another at opposite sides of the longitudinal axis.

9. An arrangement according to Claim 8, wherein said exhaust pipe means and said anti-noise chamber means are cylindrical and are concentric to the longitudinal axis.

10. An arrangement according to Claim 6, further comprising an intermediate chamber disposed between the exhaust pipe means and the anti-noise chamber means for accommodating cooling air flow to cool the exhaust pipe means, said cooling air flow in bypassing relation to the exhaust pipe and the anti-noise chamber means in a direction opposite the exhaust gas flow, said intermediate chamber opening to atmosphere substantially in the plane of the exhaust pipe outlet means.

11. An arrangement according to Claim 10, wherein cooling air flow openings open from the exhaust pipe means to the intermediate chamber and are symmetrically disposed about the circumference of the exhaust pipe means.

12. An arrangement according to Claim 11, wherein said cooling air flow openings includes at least four separate radial openings through the exhaust pipe means.

13. An arrangement according to Claim 12, wherein said cooling air flow openings includes eight separate radial openings through the exhaust pipe means.

14. An arrangement according to Claim 1, wherein the anti-noise chamber means is disposed as a concentric annular chamber surrounding the exhaust pipe.

15. An arrangement according to Claim 1, wherein the anti-noise chamber means includes a first large diameter cylindrical section connected to a second smaller diameter cylindrical section, said anti-noise speaker means being mounted

at the first cylindrical section, said second cylindrical section opening to atmosphere with an annular opening disposed at the position of the exhaust pipe outlet opening means.

16. An arrangement according to Claim 15, wherein a front end of said first cylindrical section is closed off by an annular plate connected to the outside of the exhaust pipe means, and wherein the rear of the second cylindrical section is supported at the exhaust pipe by radially extending support plates.

17. Active noise cancelling arrangement for cancelling original noise emanating from a substantially concentric opening comprising:

anti-noise chamber means surrounding the concentric opening and opening adjacent to the concentric opening via anti-noise chamber opening means concentric to said concentric opening for said original noise,

and anti-noise speaker means facing into the anti-noise chamber means for generating anti-noise pressure waves in the anti-noise chamber means such that the anti-noise pressure waves and original noise pressure waves cancel the effect of one another at the region of the concentric opening to reduce the overall noise level of the arrangement.

18. An arrangement according to Claim 17, wherein said concentric opening is an exhaust pipe outlet of an exhaust gas discharge system of a reciprocating piston internal combustion engine.

19. An arrangement according to Claim 17, wherein said engine is a driving engine for a motor boat.

20. An arrangement according to Claim 17, wherein said engine is a driving engine for a motorized road passenger vehicle.

1/5

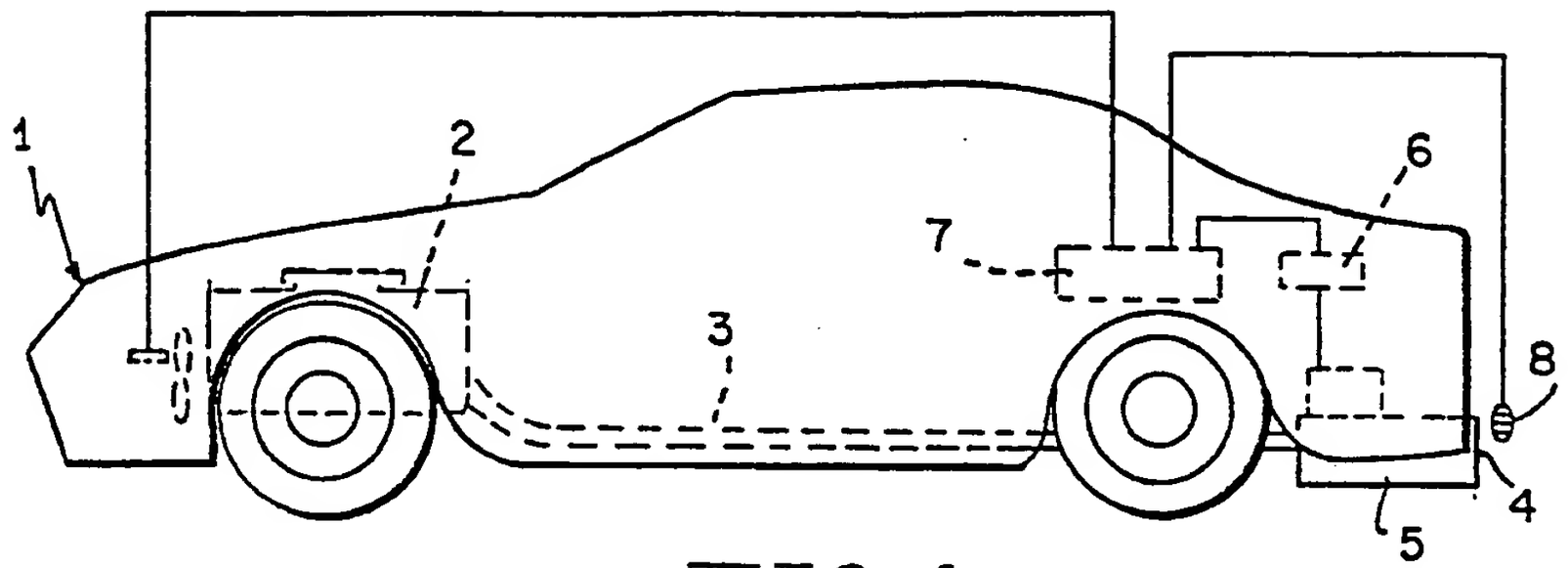


FIG. 1

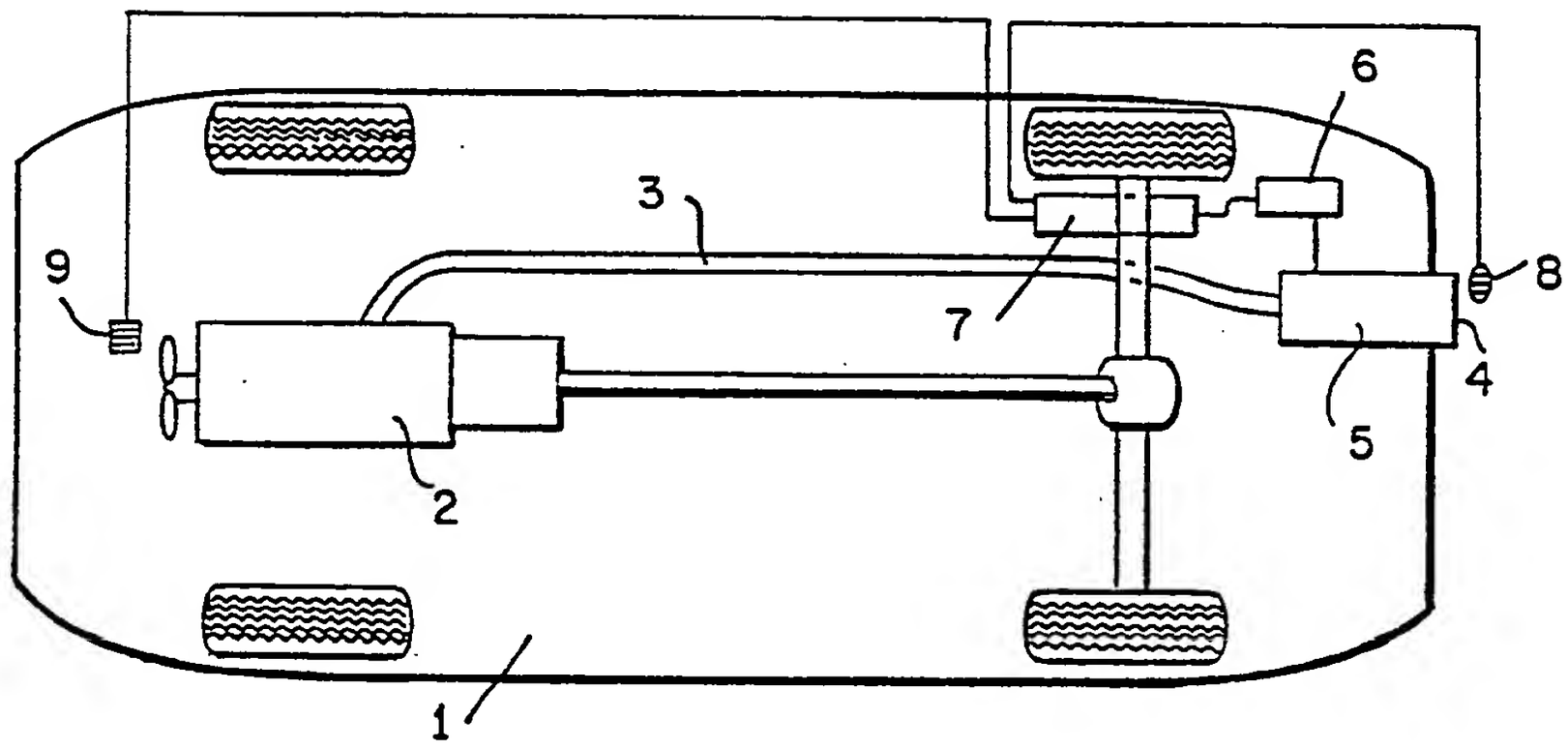


FIG. 2

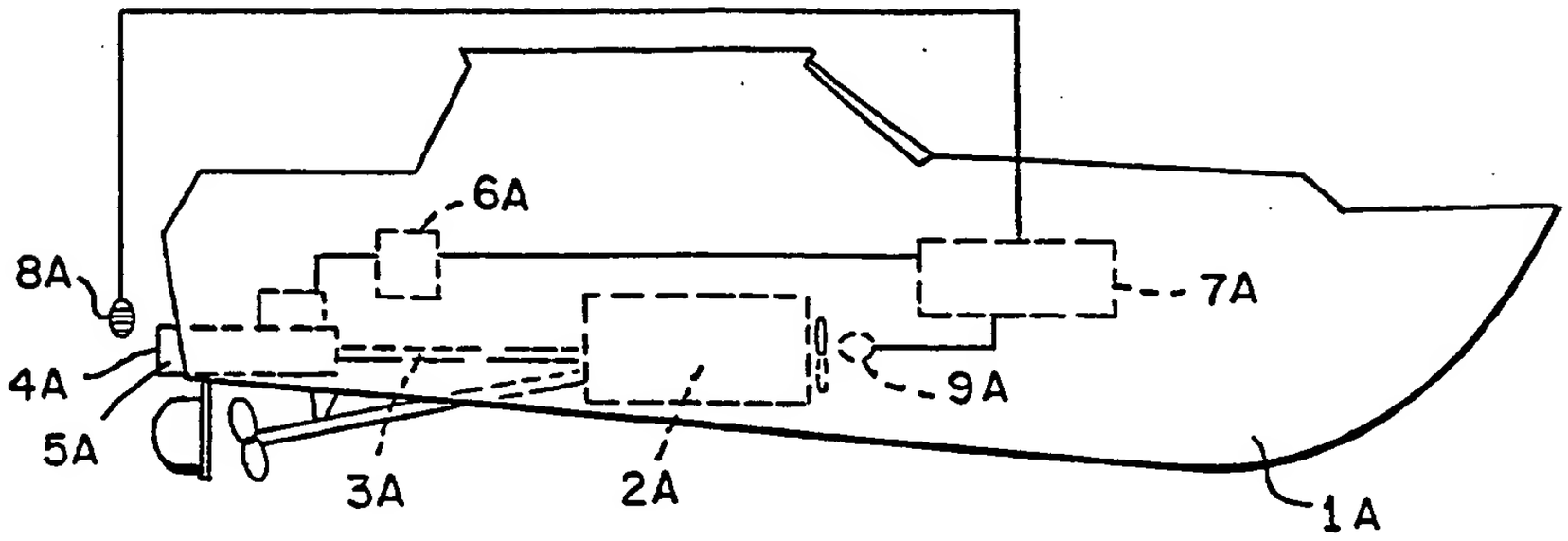


FIG. 3

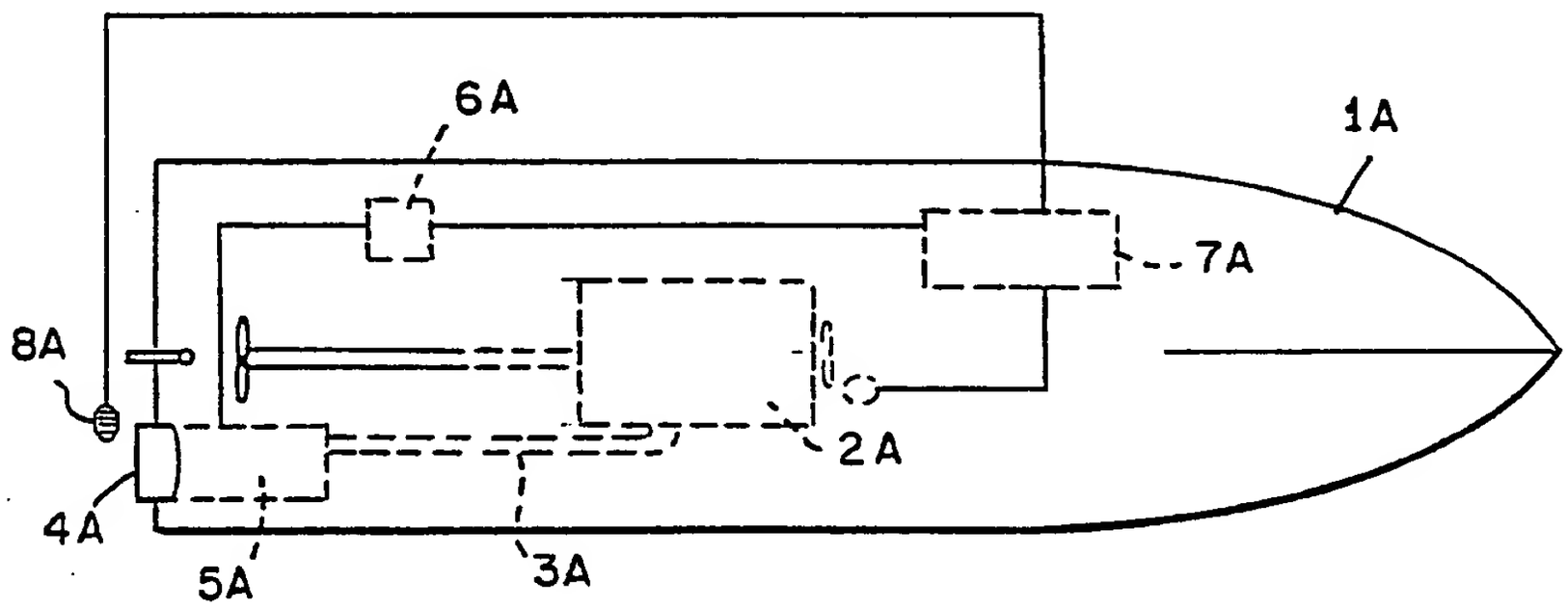


FIG 4

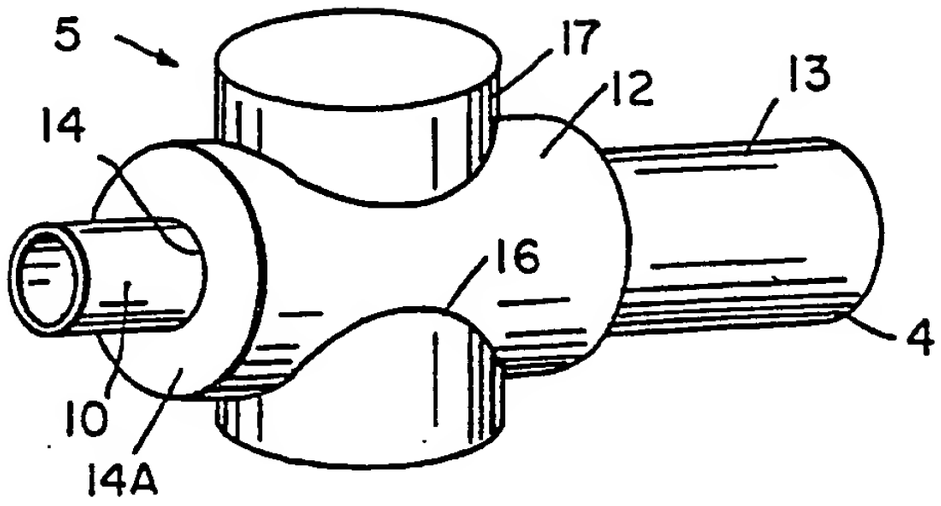


FIG. 5

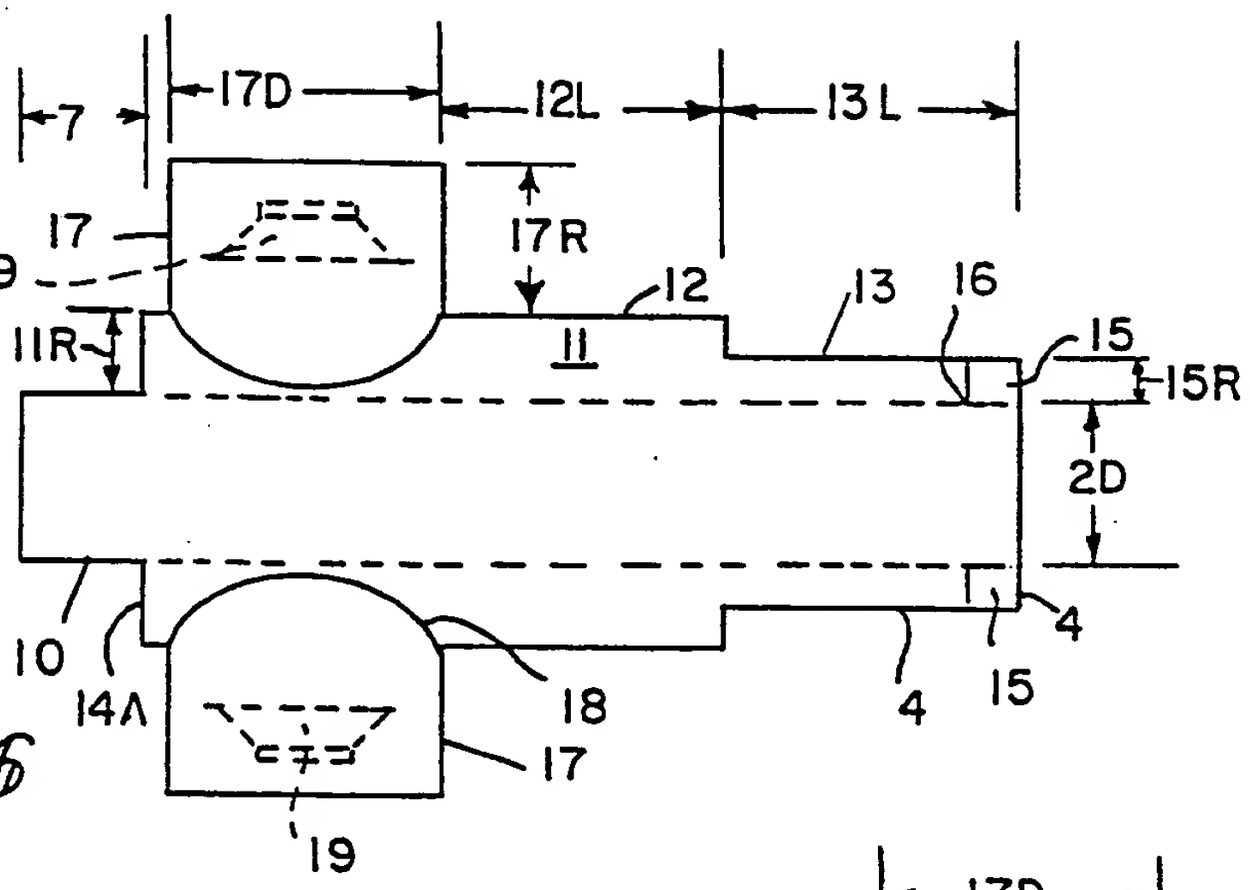


FIG. 6

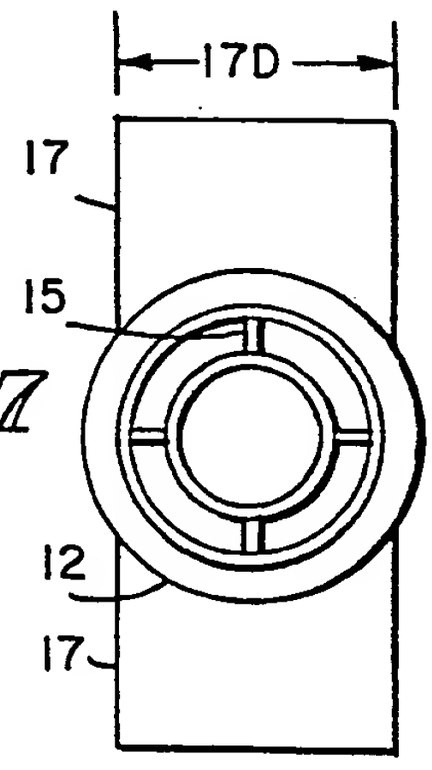


FIG. 7

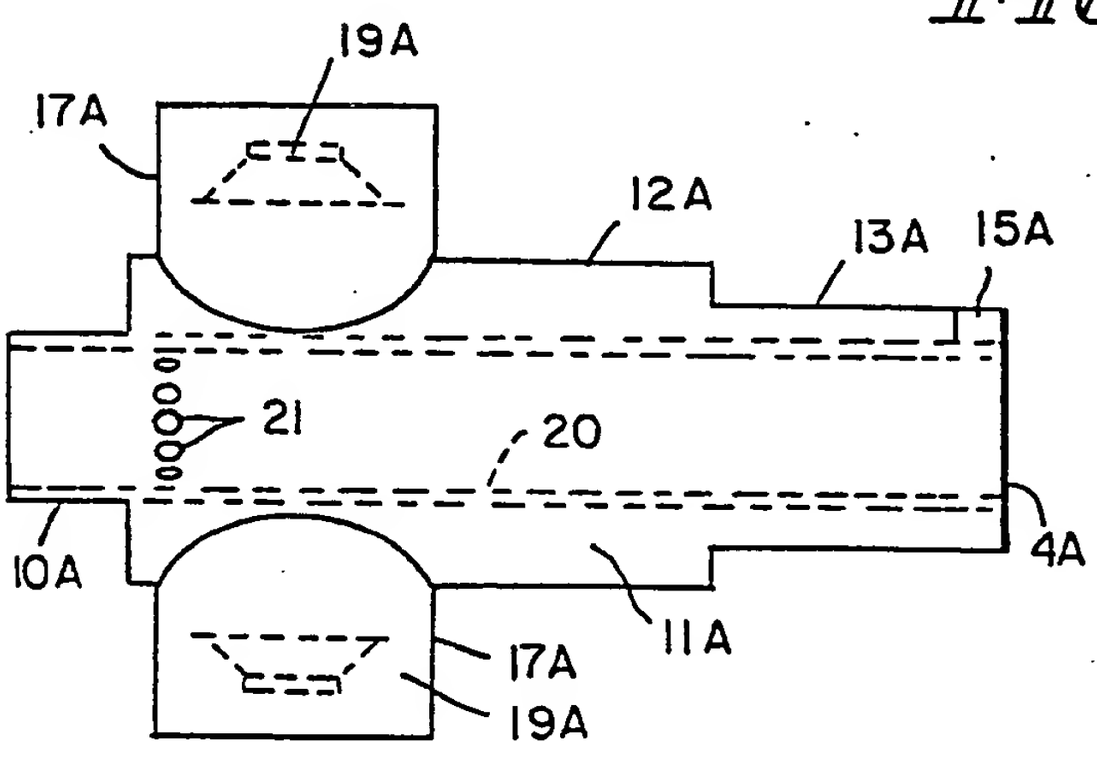


FIG. 8

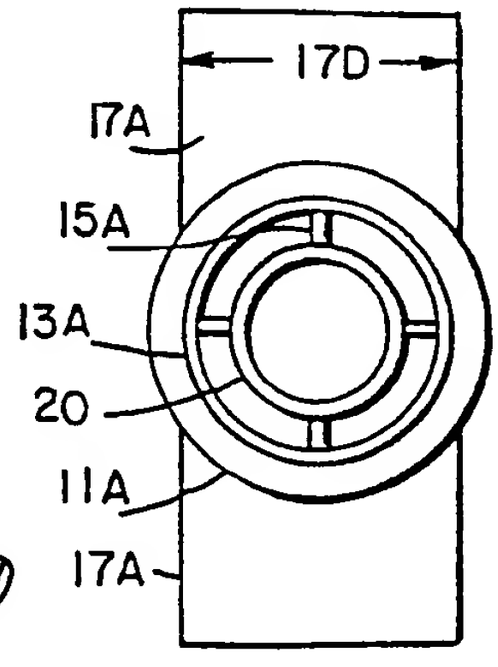


FIG. 9

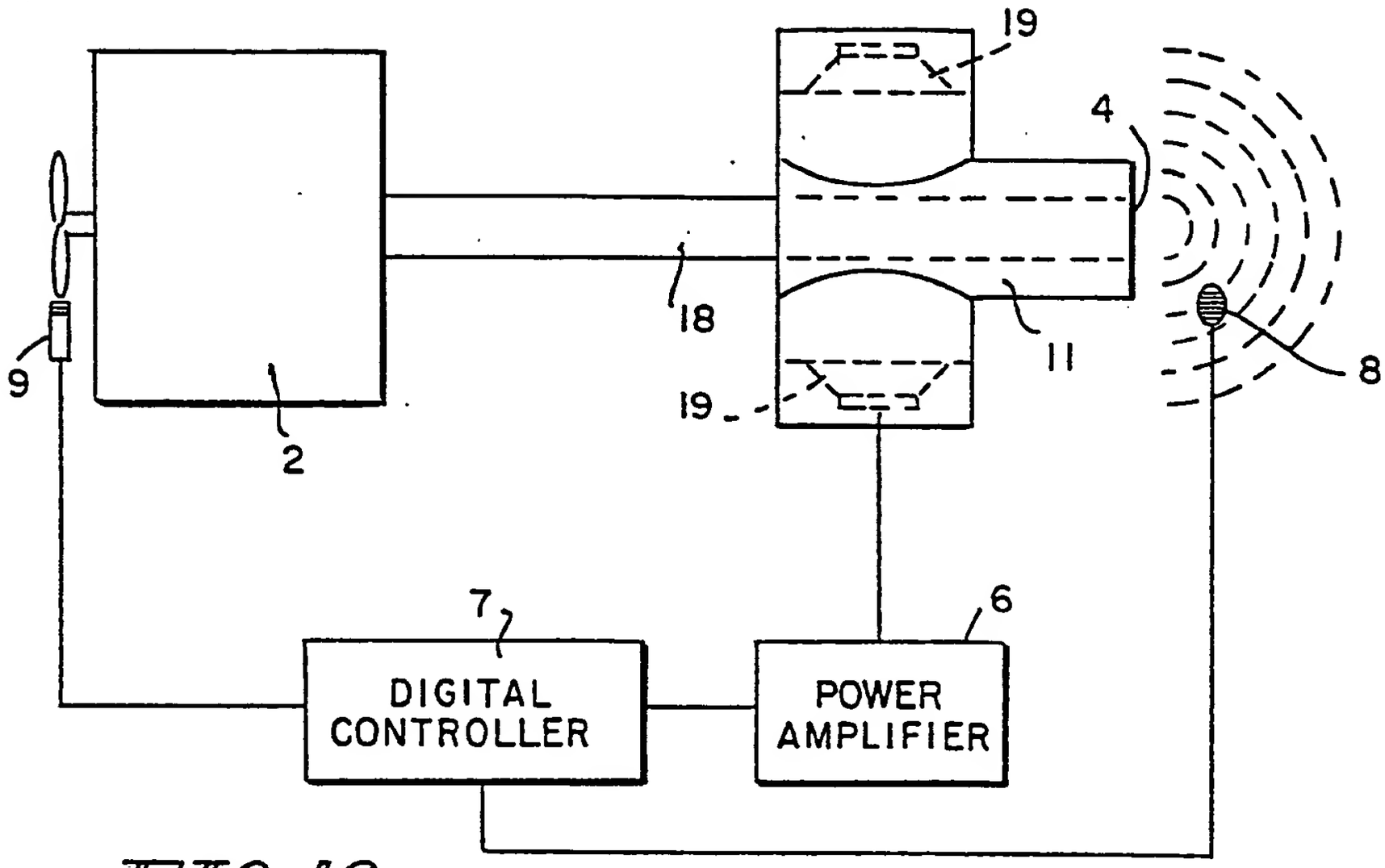

19
4
18
11
9
8
19
2
7
6
DIGITAL CONTROLLER
POWER AMPLIFIER

FIG. 10

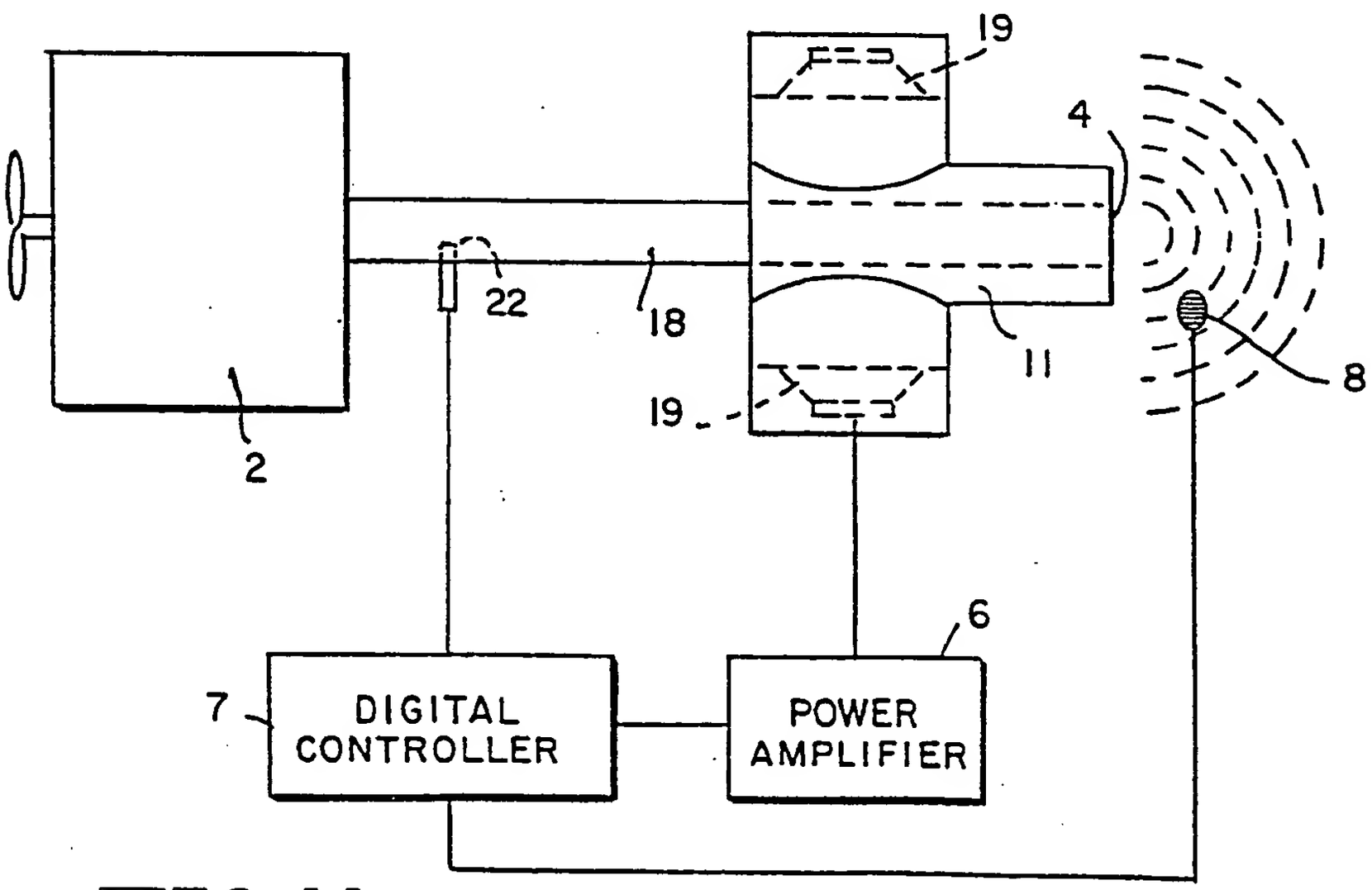

19
4
22
18
11
8
19
2
6
7
DIGITAL CONTROLLER
POWER AMPLIFIER

FIG. 11

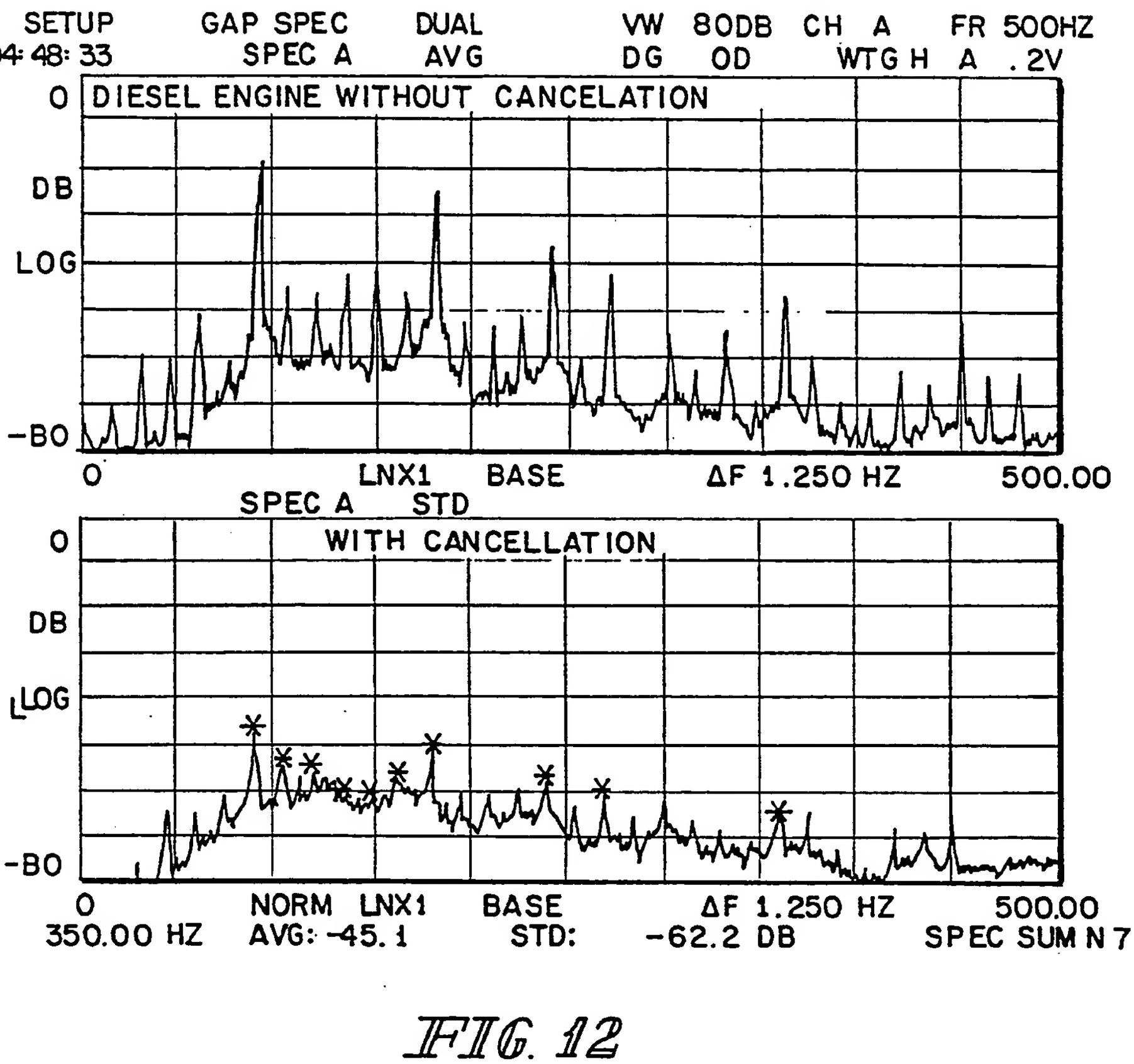

SETUP
04:48:33
GAP SPEC
SPEC A
DUAL
AVG
VW 80DB CH A FR 500HZ
DG OD WTG H A .2V
0
DIESEL ENGINE WITHOUT CANCELATION
DB
LOG
-BO
0
LNX1 BASE
ΔF 1.250 HZ
500.00
SPEC A STD
0
WITH CANCELLATION
DB
LOG
-BO
0
NORM LNX1 BASE
ΔF 1.250 HZ
500.00
350.00 HZ
AVG: -45.1
STD: -62.2 DB
SPEC SUM N 7

FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No PCT/US89/00665

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): F01N 1/06
US Cl: 181/206;381/71

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	181/206,207,227,250,269; 381/71

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US,A, 3,712,412 (HASSETT et al) 01 January 1973 , See entire document.	1-20
A	US,A, 3,826,870 (WURM et al) 30 July 1974 See entire document.	1-20
A	US,A, 4,122,303 (CHAPLIN et al) 24 October 1978, See entire document.	1-20
A	US,A, 4,177,874 (ANGELINI et al) 11 December 1979, See entire document.	1-20
A	US,A, 4,489,441 (CHAPLIN) 18 December 1984, See entire document.	1-20
Y	US,A, 4,527,282 (CHAPIN et al) 02 July 1985, See entire document.	1-20

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
05 May 1989	09 JUN 1989
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	B.R. Fuller

Form PCT/ISA/210 (second sheet) (May 1986)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
X	FR,A, 1,190,317 (SCHERRER) 12 October 1959, See entire document.	1-20
A	SU,A, 0,836,652 (GROSS) 09 June 1981, See entire document.	1-20
A	JP,A, 0,214,613 (NISSAN) 13 December 1983, See entire document.	1-20